

Application No. 10/018,662

PLEASE AMEND THE SPECIFICATION AS FOLLOWS:

Page 1, paragraph [0001] beginning at line 6:

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A photovoltaic converter which transforms high intensity light into electricity with a high efficiency is described. Its manufacture is based on standard processes used in the optoelectronic industry. The reduced cost of the electricity stems from the use of high intensity light, and its high level of efficiency (defined as the fraction of electrical power produced by the converter with respect to the incident luminous power) in relation to the efficiencies usually obtained when the converter is operating under high intensity light, as well and as the low cost of optoelectronic manufacture.

Page 1, paragraph [0002] beginning at line 15:

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One of the most promising strategies in the photovoltaic industry to achieve a reduction in the price of electricity is the use of concentration. Concentration is based on the use of optical elements which increase the intensity of the solar light falling on the solar cell (photovoltaic converter). Thus, the semiconductor material of the cell is substituted by the optical material, which is very much cheaper. There are other applications in which a photovoltaic converter transforms high intensity light. The most well known are: a) the transformation of monochromatic light emanating from a laser and ~~channeled~~ channelled through an optical fiber, in which the intensity of the light is high, not because it has been concentrated by optical methods but through the elevated irradiance of the laser, and b) the conversion of infrared light (heat) into electricity, which is known as thermophotovoltaic conversion, in which the intensity of the radiation can be elevated according to the heat source. This is understood as high intensity which exceeds 100 mW/cm^2 , which is the average level of solar radiation which reaches the Earth's surface. Thus, and from a practical point of view, which established a clear difference, in this invention high intensities are understood as those greater than 1 W/cm^2 (10 times the average solar radiation).

Page 2, paragraph [0003] beginning at line 1,

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Throughout this description and for reasons of simplicity, light is understood as ultraviolet radiation, visible and infrared, in such a way that photovoltaic conversion also encompasses thermophotovoltaic conversion. A photovoltaic converter is understood as a semiconductor device that transforms light into electricity.

Page 3, paragraph [0007] beginning at line 1:

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These three phases in the design, linked to a number of other phases in the manufacture of photovoltaic converters, have, up until now, been carried out independently, except for the use of some artificially imposed linking conditions, which have led to designs which, on occasions, are very far from optimal. There are numerous examples. Thus, for the design of a semiconductor structure ~~it was essential for~~ a certain intensity of light was assumed to enter the photovoltaic converter without knowing exactly the amount of light actually permitted to enter by the antireflection layers. In the design of the semiconductor structure the values of the specific contact resistances were not taken into account. Neither an optimum area nor size of the converter has been determined, nor has the case in which the light reaching the converter in the shape of a cone been analysed, as happens when the light is concentrated using optical elements.

Page 3, paragraph [0008] beginning at line 12:

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Therefore, and given the potential offered by photovoltaic converters based on III-V semiconductors, it is clear that if a way were found to manufacture them cheaply and in such a way that they work efficiently under intense light, and overcoming the current problems both in the design and in the achievement, these photovoltaic converters would be transformed into an attractive product and would therefore, attract both industrial and commercial interest.

Page 3, paragraph [0012] beginning at line 30:

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c) Reduced price, thanks to the use of normal techniques used in the optoelectronic industry, which has extended through which the reduction in costs is achieved, the use of devices based on III-V semiconductors, such as light emitting diodes (LEDs), laser diodes, photodiodes, etc., thanks to reductions in costs, has become widespread. It is also an industry in constant evolution and in which new techniques are becoming more and more appreciated which can be used in the manufacture of the photovoltaic converters proposed here.

Page 6, paragraph [0023] beginning at line 26:

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The tremendous advantage of this model is that it can maximize the efficiency function by means of multidimensional calculation methods, so as to be able to determine the values of several design parameters of the converter (III-V compound semiconductor structure, ohmic contacts, geometry, metal grid y and antireflection layers), which maximize the performance. This operation is known as multivariable optimization.

Page 7, paragraph [0025] beginning at line 8:

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Another added use is due to the adaptation of each specific manufacturing technology. In a photovoltaic converter there are parameters with optimum values (such as those previously mentioned). For example, the shadowing factor should be as small as possible from the point of view of maximizing the light that enters the converter but, at the same time, it is desirable for it to be as big as possible in order to diminish the series resistance. The optimum shadowing factor comes from this compromise. Additionally, there are other parameters whose best value is the maximum or minimum that can be achieved. For example, the specific contact resistance should be as small as possible. Equally, the conductivity of the metals should be as great as possible. Obviously, both the optimum values (resulting from the compromise) and the maximums and minimums are limited on many occasions by the available technology ~~available~~. Therefore, the technologically achievable values ~~condition~~ determine the rest of the converter structure. The design presented here allows these situations to be incorporated, thus making the industrial planning process possible. Consequently, for the determination of the optimum design it is necessary to know, in the first place, most of the characteristic parameters of the technology in order to later calculate the optimum values of the other parameters.

Page 8, paragraph [0027] beginning at line 3:

B10
Obviously, the model allows us to make additional refinements, such as the inclusion of series resistance in the busbar and the contact ~~terminal~~ terminals, as well as the dark diode under the busbar. However, the results of the optimization are not seen to be modified significantly, so in the search for simplicity they have not been included in this description.

Page 8, paragraph [0029] beginning at line 24, including the paragraph break between lines 2 and 3:

FIG. 1 shows the structure of the concentrator solar cell impinged by a cone of light forming an angle Θ_i with the normal of the cell surface.

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~~a section of a~~ The photovoltaic converter (A) which consists of several semiconductor layers (from 3 to n-1). The layer n is a substrate and can be as a III-V semiconductor or any other type of semiconductor such as germanium or silicon, or even a non-semiconductor substrate such as ceramic, glass or similar supports on which the semiconductor layers are stacked. The upper part of the photovoltaic converter (A) is in contact with a medium (1) which has a given refractive index. The light arrives in the shape of a cone (shaded area) from an incident medium (1) to the photovoltaic converter (A). This cone forms an angle Θ_i with the normal of the

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converter (A). The cone of light is modelled modelled as a set of light beams of different wavelengths (λ) and each ray (B) forms an angle Θ_1 with the normal of the converter and carries a certain luminous power.

Page 10, paragraph [0035] beginning at line 9:

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As a consequence of the optimum design some processes which up until now have been necessary can be relaxed or even eliminated. For example, the electrolysis of the front grid (with which an increase in the thickness of fingers can be achieved, and, as a consequence the series resistance is reduced) can be eliminated. To counterbalance the electrolysis suppression, it is enough to evaporate a thickness of the front contact by a few tenths of a micron, or if necessary by a few microns for which some types of negative photoresists can be used. This will permit a thickness of several microns thick to be achieved without rendering difficult lift-off.

Page 10, paragraph [0036] beginning at line 16:

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Both the specific design and the manufacturing procedure described for solar and heat sources can be applied to both photovoltaic converters with just one p-n semiconductor junction (single junction) and those with several different semiconductor junctions (multijunction). These are usually called tandem converters or tandem cells. These structures are of great importance since they are seen as the future of photovoltaic converters, given that they are capable of achieving higher efficiencies than the single junction ones as they take better advantage of the incident light spectrum. They can also be applied to photovoltaic converters with a monolithic connection in series, such as those used in fiber optic based power-by-light systems, in order to increase the output voltage. Finally, this invention is also an application for obtaining thermophotovoltaic converters in which the semiconductor material from which it is made, and its design is adapted to the infrared spectrum coming from a heat source. Thermophotovoltaic converters can be either single junction or multijunction (just as in the case of solar, they achieves achieve a better efficiency as they take better advantage of the infrared spectrum), and can have, or not, a monolithic connection in series.

Page 10, paragraph [0037] beginning at line 31:

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Consequently, the photovoltaic converters described in this invention are of interest in three industrial fields: a) photovoltaic solar energy for which the spectrum comes from the sun, where the converters have to be assembled to optical concentrators which increase the luminous intensity of the sun so, if higher efficiencies and reduced costs are achieved, the final cost of the

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electrical energy produced will be comparable to that obtained from fossil sources fuels; b) the production of electrical energy from heat sources such as steel or aluminium foundries, glassworks, etc. Another wide market is opening up in individual applications, to which there is no conventional electricity supply, where there were stoves or other heat sources based on combustion from which electricity could be generated; and c) the conversion of channeled light by optical fiber and coming from a laser or another source of monochromatic light. These systems, called optical fiber based power-by light, ~~by manage to~~ send electrical energy to places where its supply is impeded by problems of galvanic isolation, sparks, etc. Examples are the powering of sensors and electronics in applications such as mines, high voltage grids, the chemical and petrochemical industries, nuclear power stations, airplanes, rockets, satellites, biomedicine, among others.
